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A Novel Method for Evaluating the Acceptability of Substitutes for Cigarettes: The Experimental Tobacco Marketplace

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Abstract

Objectives: The current study tests the substitutability of nicotine replacement therapy (NRT), electronic cigarettes (ECs), and very low nicotine cigarettes (VLNCs) in the context of an online experimental tobacco marketplace (ETM) that was designed to mimic the choices of smokers under 4 policy scenarios.

Methods: Dutch cigarette smokers (N = 840) completed an online survey in July 2015. The ETM was comprised of conventional cigarettes, VLNCs, ECs (disposable/cartridge/tank systems), and NRT (lozenges/patches/tabs). All participants completed a scenario in which conventional

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Human Subjects Statement

All procedures were approved by the Institutional Review Board at the University of Waterloo.

Conflict of Interest Statement

The other authors declare that they have no conflicts of interest.

cigarettes were banned. To test additional policy scenarios participants were randomized to one of 3 experiments: 1) no VLNCs, 2) all products available, or 3) no ECs. Hypothetical weekly purchases were made when the cost for conventional cigarettes was $\frac{1}{2}$ market price (MP), MP, 2x MP, and 4x MP. Substitutability was measured by the change in estimated consumption as cigarette prices increased.

Results: Tank and cartridge ECs and VLNCs were stronger cigarette substitutes than disposable ECs and NRT products. Substitution of ECs and NRT for cigarettes was dampened when VLNCs were available.

Conclusions: The ETM offers a method to predict how smokers might respond to policies that alter the availability of potentially substitutable products available in the marketplace.

Keywords

behavioral economics; e-cigarettes; nicotine reduction; demand; price

INTRODUCTION

Innovations in product engineering are increasingly offering consumers options to use less harmful products that could be used instead of conventional factory made cigarettes (C-FMCs). Very low nicotine cigarettes (VLNCs) and electronic cigarettes (ECs) are 2 such product classes that have generated debate among researchers and policy experts.^{1–6} Evidence suggests that ECs are primarily being used as a means to reduce and/or stop smoking cigarettes,⁷ but concerns suggest that EC availability and promotion may renormalize smoking, encourage dual use, or undermine smoking cessation. VLNCs may lead to less consumption of harmful toxicants because of reduced nicotine dependence allowing for less smoking and higher rates of smoking cessation,^{8–10} however, similar products (Quest) have not fared well in markets that also sold C-FMCs. The extent of switching from cigarettes to alternative products depends on the availability and appeal of other products. Development of methods to forecast how smokers' consumption patterns might change due to the introduction of novel products or regulation would facilitate research to inform tobacco regulatory decisions.

Within a behavioral economic framework, substitution is defined as an increase in the consumption of a product where cost remains constant while the cost of a different commodity is increased (ie, cross-price elasticity).¹¹ For example, a study found that when C-FMCs prices were increased and both VLNCs and nicotine replacement therapy (NRT) were available at a constant price, consumption of both alternative products increased, thus demonstrating they functioned as substitutes.¹² A similar pattern has been found for ECs, when they were the only product available as price increased for C-FMCs.¹³ A limitation of most cross-price elasticity studies is that decisions are made when only 2 or 3 products are available, which ignores the concurrent availability of other potential substitutes that smokers encounter in the real world.

We recently developed the Experimental Tobacco Marketplace (ETM) as a means for evaluating how tobacco/nicotine product preferences and consumption vary under conditions

that typically occur in most smokers' lives, including selecting the products they wish from a large number of available products. Our initial work with the ETM was conducted in a laboratory setting where smokers were allocated funds comparable to their weekly tobacco expenditures and given 4 sets of purchase choices.¹⁴ During each set of purchases prices for C-FMCs varied, while the other products remained at a constant price. As the price of C-FMCs increased their consumption decreased, and consumption of alternative products increased (eg, Snus and ECs). The importance of product mix was also demonstrated, as substitution rates for Snus and ECs increased when another combustible product (ie, cigarillos) was removed from the ETM. As such, the ETM offers a novel method to forecast potential consequences of tobacco control regulations that might reduce or eliminate access to certain classes of tobacco products.

The current study examines the substitutability between conventional cigarettes (including roll-your-own; C-RYO) and both ECs and VLNCs in an online ETM (ie, virtual store) that presented a range of tobacco and nicotine products available only for hypothetical purchase. First, we examined the substitutability of ECs under conditions that reflected the current marketplace at the time of the study, such that VLNCs were not available. Second, we examined how adding VLNCs products to the ETM may influence product substitutability. Third, we examined the substitutability of VLNCs under a scenario in which ECs were not available. Finally, we examined the profile of purchases, if both C-FMCs and C-RYO cigarettes were no longer available. These experimental scenarios attempt to mimic how policies that might limit and/or permit products to be sold might influence product choices by smokers and thus provide a basis for forecasting how smokers would respond under different policy scenarios.

METHODS

Participants

Participants were recruited by a commercial online survey research firm (TNS NIPO) in April 2014 to take part in a web-based survey. The ETM was administered as part of a follow-up survey in July 2015 (N = 840). All members of the consumer panel resided in the Netherlands, where a VLNC was planned to be marketed and made available. The VLNC was never introduced into the Netherlands because the government had several concerns: 1) the implied claim the product contained no nicotine (because of the brand name, Magic Zero), when in fact the product did contain very low levels of nicotine; and 2) because the tobacco used in the product was genetically modified which potentially violated laws regulating the marketing of genetically modified foods. As a result of the product not being introduced into the marketplace as originally planned we revised our study to examine hypothetical purchasing behavior through the ETM. Prospective participants had to meet the following inclusion criteria: 16 years of age or older, smoked at least 100 cigarettes in their lifetime, and reported smoking cigarettes daily over the past 30 days. Participants were randomized to experiments 1, 2, or 3, and all completed experiment 4. As described below, product availability varied across experiments. As displayed in Table 1, sample characteristics were similar across experiments. Participants were compensated by the

survey firm with NIPO Points, which can be used to acquire gifts. All procedures were approved by the Institutional Review Board at the University of Waterloo.

Procedure and Measures

After obtaining informed consent, participants completed an online survey and the ETM experiments. The survey assessed demographic variables such as age, sex, income (categorized into: low =< €1750, moderate = €1750-€3000, and high => €3000 per month), and education (categorized into: low = primary education and lower prevocational secondary education, moderate = middle prevocational secondary education and secondary vocational education, and high = senior general secondary education, pre-university education, and higher professional education). Nicotine dependence was measured by the Heaviness of Smoking Index (HSI),¹⁵ and participants reported motivation to stop smoking.¹⁶ Motivation to quit was categorized into 3 levels: none (did not want to quit), low (wanted to quit, but not sure when), and high (intentions to quit within 3 months). The parent study included additional assessments (eg, reasons for using products, exposure to and awareness of products, perceptions, beliefs, and attitudes about products), which are not analyzed herein.

ETM overview.—Weekly purchases were made during 4 randomly ordered conditions based on the average market price (MP) of C-FMCs and C-RYO: 1/2x MP, MP, 2x MP, and 4x MP. Price was held constant for all other products, based off their MP. As prices for C-FMCs and C-RYO increased, changes in their consumption was used to estimate own-price elasticity (ie, price sensitivity) and changes in other product consumption was used to estimate cross-price elasticity (ie, substitution). Across all 4 conditions, participants were given an account balance based on their weekly expenditure for cigarettes. This was calculated from self-reported cigarettes smoked per day (cpd) multiplied by the MP per cigarette (€30) and 7 days. Participants were instructed to purchase the number of products expected to be used over the next 7 days, and to assume they did not have access to any other nicotine/tobacco products during this time period. Participants were also instructed to assume that in one week any unused products would be thrown away (ie, no stockpiling products or saving them for a later date). Colorized pictures of the most popular products were displayed on a webpage, along with product descriptions, nicotine content, and price (see product lists below). Participants were instructed to assume that the brand and quality of the products were their personal preference, even if their chosen brand and quality was not pictured. After participants made initial product selections they were shown a checkout page with account balance displayed. At this point they were able to confirm purchases or return to the store to alter selections.

Experiment 1 products.—Product availability mirrored market conditions (ie, no VLNCs), including: Marlboro Red C-FMCs (19 per pack; price varied at €3,10, €6,20, €12,40, €24,80); Van Nelle C-RYO tobacco (50g; ~2.5 packs FMCs; price varied at €4,75, €9,50, €19,00, €38,00); Flavor Vapes disposable EC (16mg nicotine; ~1 pack FMCs; €9,95); E-Smoking EC cartridges (5ct with 16mg nicotine each; ~4 packs FMCs; €9,95); Joyetech e-liquid for tank EC (10ml with 160mg nicotine; ~8.5 packs FMCs; €4,75); Nicorette gum (30ct with 2mg nicotine each; ~3 packs FMCs; €7,95); Nicotinell lozenges (36ct with 2mg nicotine each; ~3 packs FMCs; €11,19); NiQuitin patch (7ct with 21mg nicotine each; ~7

packs FMCs; €20,99). Participants were instructed to assume they already had rolling papers available for the C-RYO tobacco, and EC units available for the cartridge and tank refills. Hypothetical weekly purchases were made for conventional cigarettes, ECs, and NRT.

Experiment 2 products.—Product availability was identical to that of Experiment 1, except the ETM included 2 VLNCs. VLNC pricing was set at the MP for conventional tobacco: VLN-FMCs (19 per pack; €6,20) and VLN-RYO (50g; €9,50). Magic Zero was the name of the VLNC brand displayed in the ETM. Hypothetical weekly purchases were made for conventional cigarettes, VLNCs, ECs, and NRT.

Experiment 3 products.—Product availability was identical to that of Experiment 2, except the ETM did not include EC products. Hypothetical weekly purchases were made for conventional cigarettes, VLNCs, and NRT.

Experiment 4 products.—Products in the ETM were identical to those in Experiment 2, except conventional cigarettes products were excluded. Hypothetical weekly purchases were made for VLNCs, ECs, and NRT. All participants from experiments 1–3 completed this scenario. As a single shot purchase condition (ie, low burden), this experiment would provide data on how smokers may allocate their purchases if conventional cigarettes were banned.

Data Analyses

Equivalent units were computed to allow comparability across products, standardized by the number of cigarette equivalents in each product. For conventional cigarettes and VLNCs this equated to 19 per pack of FMCs and 47.5 per package of RYO. For the other products, number of cigarette equivalents was based on delivery of ~1mg of nicotine: EC-disposable (~1 pack = 19 cigarettes); EC-cartridges (~4 packs = 76 cigarettes); EC-tank (~8.5 packs = 161.5 cigarettes); NRT-gum (~3 packs = 57 cigarettes); NRT-lozenges (~3 packs = 57 cigarettes); NRT-patch (~7 packs = 133 cigarettes).

Own-price elasticity (ie, α) for C-FMCs and C-RYO was derived through exponential demand curve modeling,¹⁷ $\log_{10} Q = \log_{10} Q_0 + k \left(e^{-\alpha Q_0 C} - 1 \right)$. For this equation, Q = consumption at a given cost, Q_0 = consumption when cost is zero, k = a constant that denotes the range of consumption in log powers of 10 (2 for the current study), α = the rate of decline of consumption in standardized cost, and C = cost. Modeling was conducted using GraphPad Prism version 7 software (La Jolla, CA). Means (M) and standard errors (SE) for C-FMC and C-RYO elasticity estimates are reported below. Extra sum-of-squares F tests were used to test for differences between C-FMC and C-RYO elasticity estimates. Cross-price elasticity for all other products was calculated from linear regression of group means for the fixed price product as a function of unit price increases for conventional cigarettes. Substitution, complementation and independence are evident when cross-price elasticity of demand values are positive, negative, or near zero, respectively. Consistent with the original ETM study,¹⁴ positive slopes statistically significant from zero (two tailed $\alpha < .05$) indicate a product functioned as a substitute for conventional tobacco. To replicate and extend from

the original ETM study we analyzed 10cpd smokers and < 10cpd smokers separately. The latter were excluded from the initial ETM study so the current study examines whether the ETM provides similar substitution profiles across a broader range of smokers. Results for < 10cpd smokers are described below, with additional details depicted in supplemental tables and figures.

RESULTS

Experiment 1: Current Market Conditions (ie, no VLNCs)

Own-price elasticity.—As displayed in Figure 1 and Supplemental Figure 1 (panel a), demand for conventional tobacco decreased as price increased. Excellent fit was observed for group mean values of C-FMCs ($R^2 = .995$) and C-RYO ($R^2 = .998$) for 10cpd smokers. A significant difference in elasticity between C-FMCs ($M = .0066$; $SE = .0003$) and C-RYO ($M = .0050$; $SE = .0001$; $p = .007$) was detected, such that C-FMC consumption was more price sensitive (ie, higher α). Excellent fit was also observed for group mean values of C-FMCs ($R^2 = .997$) and C-RYO ($R^2 = .976$) for < 10cpd smokers. The elasticity estimates of C-FMCs ($M = .0075$; $SE = .0002$) and C-RYO ($M = .0089$; $SE = .0007$; $p = .09$) were not statistically different.

Cross-price elasticity.—Figure 1 and Supplemental Figure 1 (panel a) depict the number of equivalent units (ie, C-FMCs) purchased for all products as conventional tobacco price increased, with cross-price elasticity slopes listed in Table 2. EC-cartridges, EC-tank refill, and NRT-lozenges were the only products with slopes statistically different from zero for 10cpd smokers. Cross-price elasticity was highest for EC-tank, followed by EC-cartridges, and then NRT-lozenges. A similar pattern was observed for < 10cpd smokers (see Supplemental Table 1), although EC-tank refill and NRT-lozenges were the only products that were treated as substitutes for conventional tobacco. The percentage of the sample to purchase each product and range of units purchased is shown in Table 3 and Supplemental Table 2. Rates of not purchasing any product (ie, quitting) increased as the price of conventional cigarettes increased for both 10cpd (2.2%–7.8%) and < 10cpd smokers (1.4%–15.7%).

Experiment 2: VLNCs Added

Own-price elasticity.—As displayed in Figure 1 and Supplemental Figure 1 (panel b), demand for conventional tobacco decreased as price increased. Excellent fit was observed for group mean values of C-FMCs ($R^2 = .997$) and C-RYO ($R^2 = .969$) for 10cpd smokers. No significant difference between C-FMCs ($M = .0068$; $SE = .0003$) and C-RYO ($M = .0060$; $SE = .0005$; $p = .23$) was observed. Excellent fit was also observed for group mean values of C-FMCs ($R^2 = .992$) and C-RYO ($R^2 = .997$) for < 10cpd smokers. Elasticity estimates were significantly different between C-FMCs ($M = .0079$; $SE = .0004$) and C-RYO ($M = .0115$; $SE = .0007$; $p = .01$) suggesting that C-RYO consumption was more price sensitive.

Cross-price elasticity.—Figure 1 and Supplemental Figure 1 (panel b) depict the number of equivalent units purchased for all products as conventional tobacco price increased, with

cross-price elasticity slopes listed in Table 2. EC-cartridges and both VLNCs functioned as substitutes for 10cpd smokers. Although EC-Tank had the greatest slope, this was not statistically significant. A similar pattern was observed for < 10cpd smokers (see Supplemental Table 1), although VLNCs were the only substitutes. The percentage of the sample to purchase each product and range of units purchased is shown in Table 3 and Supplemental Table 2. Rates of not purchasing any product (ie, quitting) increased as the price of conventional cigarettes increased for both 10cpd (2.6%–7.3%) and < 10cpd smokers (1.4%–8.6%).

Experiment 3: VLNCs Added and ECs Banned

Own-price elasticity.—As displayed in Figure 1 and Supplemental Figure 1 (panel c), demand for conventional tobacco decreased as price increased. Excellent fit was observed for group mean values of C-FMCs ($R^2 = .990$) and C-RYO ($R^2 = .976$) for 10cpd smokers. Elasticity estimates between C-FMCs ($M = .0074$; $SE = .0006$) and C-RYO ($M = .0053$; $SE = .0004$; $p = .04$) were statistically significant such that C-FMC consumption was more price sensitive. Good fit was observed for group mean values of C-FMCs ($R^2 = .976$) and C-RYO ($R^2 = .720$) for < 10cpd smokers. No significant difference between C-FMCs ($M = .0083$; $SE = .0008$) and C-RYO ($M = .0105$; $SE = .0030$; $p = .47$) was detected.

Cross-price elasticity.—Figure 1 and Supplemental Figure 1 (panel c) depict the number of equivalent units purchased for all products as conventional tobacco price increased, with cross-price elasticity slopes listed in Table 2. Both VLNCs functioned as substitutes for 10cpd smokers. A similar pattern was observed for < 10cpd smokers (see Supplemental Table 1), although VLN-FMC was the only substitute. The percentage of the sample to purchase each product and range of units purchased is shown in Table 3 and Supplemental Table 2. Rates of not purchasing any product (ie, quitting) increased as the price of conventional cigarettes increased for both 10cpd (3.7%–11.4%) and < 10cpd smokers (6.0%–20.9%).

Experiment 4: VLNCs Added and Conventional Cigarettes Banned

Figure 2 and Supplemental Figure 2 display the number of equivalent units purchased for all products when conventional tobacco was banned. Similar to scenarios in which prices of conventional cigarettes were increased, 10cpd smokers instead purchased VLN-FMC, VLN-RYO, EC-cartridge, and EC-tank products. Purchasing of EC-disposable and NRT products was minimal. VLN-FMCs had the highest rate of purchase (35.2%; range=0–14), followed by VLN-RYO (23.9%; range = 0–8), EC-Tank (19.6%; range = 0–10), EC-cartridges (15.3%; range = 0–8), EC-disposable (6.8%; range = 0–5), NRT-gum (5.5%; range = 0–3), NRT-patch (5.5%; range = 0–2), and NRT-lozenge (4.6%; range = 0–3). A considerable portion of 10cpd smokers indicated they would not purchase any of the alternative products (22.4%). A similar pattern was observed for < 10cpd smokers. VLN-FMCs had the highest rate of purchase (45.4%; range = 0–6), followed by VLN-RYO (21.3%; range = 0–4), EC-cartridges (10.6%; range = 0–3), EC-Tank (10.1%; range = 0–7), EC-disposable (10.1%; range = 0–3), NRT-lozenge (8.2%; range = 0–3), NRT-gum (6.8%; range = 0–4), and NRT-patch (5.3%; range = 0–1). A considerable portion of < 10cpd smokers indicated they would not purchase any of the alternative products (19.8%).

DISCUSSION

The current study advances the behavioral economic approach in several ways. The majority of own-price elasticity studies only include heavier smokers (≥ 10 cpd) and demonstrate that C-FMC consumption is price sensitive.^{18,19} We found that this pattern of price sensitivity extends to C-RYO, and for lighter (< 10 cpd) smokers. Cross-price elasticity studies traditionally examine substitution with conventional cigarettes and one or 2 alternative products.²⁰ These studies provide evidence that a product is, or is not, a viable substitute, however we believe the ETM will provide more accurate substitution estimates because purchases are made in a context where the breadth of products more closely mirrors the real world. Furthermore, while most behavioral economic studies have been conducted in a laboratory setting, the current study demonstrates the feasibility of implementing the ETM in an online format. Our findings highlight the value of the ETM methodology as a means to predict complex interactions of tobacco product availability on consumption patterns.

Experiment 1 results suggest that Dutch smokers would initially switch to EC-cartridges, EC-tank, and NRT-lozenges if prices for conventional tobacco were to increase under current market conditions. When VLNCs were added to the market (Experiment 2) EC-tank and NRT-lozenges were no longer substitutes for C-FMCs. In a scenario in which VLNCs were available in the marketplace, but ECs were banned (Experiment 3), VLNCs (either VLN-FMCs or VLN-RYO) were perceived as the only viable substitutes for C-FMCs. Finally, Experiment 4 suggests most smokers would initially shift towards use of VLNC, EC-cartridge, EC-tank products, or quit using nicotine/tobacco altogether, if C-FMCs were banned. Variability of conventional tobacco substitutes across experiments indicates product availability may influence consumption of other products. Heavier (≥ 10 cpd) and lighter (< 10 cpd) smokers had similar, but not identical, substitution profiles. Lighter smokers are often excluded from behavioral economic studies, but the ETM appears to be a robust methodology that can be applied across a wide continuum of smokers.

Several limitations to external validity are worth noting. First, the current sample was recruited from a commercial online survey panel and therefore underrepresents smokers without ready access to the internet. However, we also view the online administration of the ETM as a potential strength because this approach is more efficient than traditional laboratory-based methods, which may only represent a small portion of the smoking population willing to visit a laboratory. Second, we presented a picture of one specific brand for each type of product, so results may not generalize to other products. We instructed participants to assume the products were their preferred type and quality regardless of the picture, but future studies could rectify this limitation by comparing multiple brands of each product. Third, all responses were hypothetical and thus may not reflect naturalistic purchasing behaviors. However, prior studies suggest concordance between estimates from hypothetical purchase tasks and consumption patterns.^{18,21–23} Regardless, future studies that test the predictive validity of the ETM will further delineate the utility of this novel approach. Prospective studies are required to see if this sophisticated method provides more accurate prediction of changing behavior than simpler methods such as simply asking the person how likely they are to use a product.

Additionally, participants were daily smokers but may have had little to no experience with the alternative products. Only 7% of the sample had used an EC (any type) in the past 30 days, 4% had used NRT (any type) in the past 15 months, and we assume that no one had used VLNCs. Prior use of similar products will likely influence substitution estimates. For example, substitutability of a product could decrease if smokers had the chance to use them and were dissatisfied with the experience (eg, taste). Product acceptability, as measured by study retention, was lower for smokers randomized to abruptly transition to VLNCs and for those who rated taste less favorably.²³ In the largest clinical trial of VLNCs, participants randomized to receive 6 weeks of VLNCs (2.4 mg/g) reported a reduction in estimated consumption of study cigarettes relative to those provided normal nicotine content cigarettes (15.8 mg/g).²¹ Future studies should examine how ETM purchasing patterns change over time as a function of product use, which may improve the accuracy of substitution estimates.

IMPLICATIONS FOR TOBACCO REGULATION

The online ETM can be used to estimate conventional cigarette demand, and detect potential substitutes through presentation of various product mixes. Overall, tank and cartridge ECs and VLNCs were stronger substitutes than disposable ECs and NRT products. Substitution of ECs and NRT was dampened when VLNCs were made available, but EC availability had a negligible impact on VLNC substitutability. Thus, the ETM offers a novel method to test how smokers might initially respond to the introduction of new products (ie, VLNCs) and policies that alter the availability of potentially substitutable products available in the marketplace. However, it is important that similar studies be conducted after people have had the opportunity to try the products to see if initial preferences are sustained. This methodology could be adapted to examine the appeal of forthcoming products (eg, heat-not-burn), and policies that could influence the substitutability of existing products (eg, flavors, labeling, price).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Conventional cigarette demand and alternative product purchase data (means and standard errors), across Experiments 1–3 (10cpd smokers).

Figure 2.
Alternative product purchase data (means and standard errors) for Experiment 4 (10cpd smokers).

Table 1

Sample Characteristics

Characteristic	Experiment 1: Current market (no VLNCs)	Experiment 2: Alternate scenario 1 (VLNCs added)	Experiment 3: Alternate scenario 2 (VLNCs added/ ECs banned)	Total/ Experiment 4: (Conventional tobacco banned)
	N = 250	N = 304	N = 286	N = 840
Age, M (SD)	37.96 (17.78)	37.84 (18.09)	38.97 (17.78)	38.26 (17.88)
Sex, N (%)				
Male	124 (50%)	165 (54%)	143 (50%)	432 (51%)
Female	126 (50%)	139 (46%)	143 (50%)	408 (49%)
Education, N (%)				
Low	56 (22%)	78 (26%)	70 (24%)	204 (24%)
Moderate	125 (50%)	138 (45%)	139 (49%)	402 (48%)
High	66 (26%)	84 (28%)	76 (27%)	226 (27%)
Unknown	3 (1%)	4 (1%)	1 (0%)	8 (1%)
Income, N (%)				
Low	57 (23%)	70 (23%)	62 (22%)	189 (23%)
Moderate	67 (27%)	68 (22%)	82 (29%)	217 (26%)
High	62 (25%)	72 (24%)	52 (18%)	186 (22%)
Don't know	64 (26%)	94 (31%)	90 (31%)	248 (30%)
Quit Motivation, N (%)				
Low	180 (72%)	195 (64%)	193 (67%)	568 (68%)
Moderate	62 (25%)	96 (32%)	79 (28%)	237 (28%)
High	8 (3%)	13 (4%)	14 (5%)	35 (4%)
Type of cigarette smoked, N (%)				
C-FMCs Mostly	106 (42%)	145 (48%)	121 (43%)	372 (44%)
C-RYO Mostly	137 (55%)	141 (46%)	148 (52%)	426 (51%)
C-FMCs and C-RYO Evenly	7 (3%)	18 (6%)	17 (6%)	42 (5%)
CPD groups, N (%)				
10cpd	180 (72%)	234 (77%)	219 (77%)	633 (75%)
< 10cpd	70 (28%)	70 (23%)	67 (23%)	207 (25%)
CPD, mean (SD)	14.05 (7.04)	14.15 (7.33)	13.84 (6.81)	14.02 (7.06)
HSI, mean (SD)	1.99 (1.39)	2.02 (1.41)	2.00 (1.38)	2.00 (1.39)
EC use (past 30 days), N (%)				
Yes	13 (5%)	27 (9%)	20 (7%)	60 (7%)
No	237 (95%)	277 (91%)	266 (93%)	780 (93%)
NRT use (past 15 months), N (%)				
Yes	7 (3%)	15 (5%)	14 (5%)	36 (4%)
No	243 (97%)	289 (95%)	272 (95%)	804 (96%)

Notes: C-FMCs = conventional factory made cigarettes; C-RYO = conventional roll-your-own; CPD = cigarettes per day; HSI = Heaviness of smoking index; SD = standard deviation; VLNCs = very low nicotine cigarettes; ECs = electronic cigarettes; NRT = nicotine replacement therapy

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Table 2

Cross-Price Elasticity Estimates (10cpd smokers)

	Slope/ cross-price elasticity	95% confidence intervals	F-test	p
Experiment 1				
VLN-FMCs	-	-	-	-
VLN-RYO	-	-	-	-
EC-Disposable	1.05	-0.59 to 2.70	1.57	0.21
EC-Cartridges	20.62	10.29 to 30.95	15.30	< 0.001 *
EC-Tank	83.16	40.19 to 126.1	14.39	< 0.001 *
NRT-Gum	3.47	-1.05 to 8.00	2.258	0.13
NRT-Lozenges	5.58	1.66 to 9.50	7.77	0.006 *
NRT-Patch	4.42	-2.21 to 11.05	1.705	0.19
Experiment 2				
VLN-FMCs	13.08	7.64 to 18.53	22.17	< 0.001 *
VLN-RYO	12.41	5.05 to 19.76	10.93	0.001 *
EC-Disposable	0.27	-0.65 to 1.20	0.33	0.57
EC-Cartridges	9.28	1.55 to 17.01	5.54	0.02 *
EC-Tank	17.88	-9.18 to 44.94	1.68	0.20
NRT-Gum	1.70	-1.56 to 4.96	1.05	0.31
NRT-Lozenges	1.05	-1.02 to 3.13	0.99	0.32
NRT-Patch	3.02	-0.82 to 6.86	2.37	0.12
Experiment 3				
VLN-FMCs	18.62	12.92 to 24.32	41.01	< 0.001 *
VLN-RYO	13.19	6.58 to 19.79	15.32	< 0.001 *
EC-Disposable	-	-	-	-
EC-Cartridges	-	-	-	-
EC-Tank	-	-	-	-
NRT-Gum	2.33	-1.16 to 5.83	1.71	0.19
NRT-Lozenges	3.37	-0.22 to 6.96	3.39	0.07
NRT-Patch	2.82	-3.67 to 9.31	0.73	0.39

Notes:

* slope statistically significant from zero

VLN-FMCs = very low nicotine factory made cigarettes; VLN-RYO = very low nicotine roll-your-own; EC = electronic cigarette; NRT = nicotine replacement therapy

Table 3

Percent and Range of Products Purchased Across Conventional Tobacco Prices (10cpd Smokers)

	Percent Purchasing across Conventional Tobacco Prices				Range of Products Purchased across Conventional Tobacco Prices			
	1/2x	Market Price	2x	4x	1/2x	Market Price	2x	4x
Experiment 1								
C-FMCs	64.4%	63.3%	42.8%	34.4%	0–20	0–14	0–5	0–2
C-RYO	46.7%	42.2%	37.8%	26.1%	0–12	0–7	0–4	0–2
VLN-FMCs	-	-	-	-	-	-	-	-
VLN-RYO	-	-	-	-	-	-	-	-
EC-Disposable	4.4%	3.9%	4.4%	6.1%	0–3	0–2	0–3	0–6
EC-Cartridges	7.2%	7.2%	11.7%	17.2%	0–3	0–2	0–4	0–6
EC-Tank	12.8%	11.7%	18.9%	19.4%	0–3	0–9	0–9	0–9
NRT-Gum	3.3%	3.9%	6.1%	8.9%	0–3	0–4	0–2	0–2
NRT-Lozenges	0.6%	2.8%	5.6%	5.6%	0–1	0–2	0–4	0–3
NRT-Patch	3.9%	5.0%	5.0%	6.7%	0–1	0–1	0–1	0–2
None (ie, quit)	2.2%	3.9%	6.7%	7.8%	-	-	-	-
Experiment 2								
C-FMCs	63.2%	62.0%	40.6%	26.5%	0–29	0–14	0–7	0–3
C-RYO	35.9%	35.0%	29.9%	24.4%	0–17	0–7	0–5	0–3
VLN-FMCs	11.1%	12.8%	20.5%	25.2%	0–7	0–6	0–9	0–9
VLN-RYO	6.8%	9.0%	12.4%	15.8%	0–4	0–8	0–8	0–8
EC-Disposable	1.7%	2.6%	0.4%	4.3%	0–4	0–1	0–1	0–4
EC-Cartridges	3.8%	5.1%	4.7%	9.4%	0–4	0–4	0–4	0–4
EC-Tank	7.7%	10.3%	14.5%	13.7%	0–10	0–5	0–10	0–8
NRT-Gum	3.4%	3.4%	3.4%	5.6%	0–2	0–4	0–2	0–3
NRT-Lozenges	1.7%	2.1%	3.8%	2.1%	0–1	0–2	0–2	0–2
NRT-Patch	1.3%	1.7%	2.1%	3.0%	0–1	0–1	0–1	0–2
None (ie, quit)	2.6%	3.4%	6.8%	7.3%	-	-	-	-
Experiment 3								
C-FMCs	60.7%	58.0%	39.3%	21.9%	0–22	0–11	0–5	0–2
C-RYO	43.8%	38.4%	30.6%	27.9%	0–10	0–6	0–4	0–2
VLN-FMCs	9.1%	13.7%	20.5%	30.6%	0–7	0–6	0–7	0–9
VLN-RYO	7.3%	8.7%	15.5%	17.4%	0–4	0–4	0–4	0–4
EC-Disposable	-	-	-	-	-	-	-	-
EC-Cartridges	-	-	-	-	-	-	-	-
EC-Tank	-	-	-	-	-	-	-	-
NRT-Gum	3.7%	4.1%	8.2%	6.4%	0–3	0–3	0–1	0–4
NRT-Lozenges	3.7%	3.2%	3.2%	7.3%	0–3	0–2	0–3	0–3
NRT-Patch	3.2%	3.7%	5.0%	5.5%	0–2	0–2	0–2	0–2

	Percent Purchasing across Conventional Tobacco Prices				Range of Products Purchased across Conventional Tobacco Prices			
	1/2x	Market Price	2x	4x	1/2x	Market Price	2x	4x
None (ie, quit)	3.7%	5.9%	7.8%	11.4%	-	-	-	-